A Model for Air Flow in Ventilated Cavities Implemented in a Tool for Whole-Building Hygrothermal Analysis

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A Model for Air Flow in **Ventilated Cavities** Implemented in a Tool for Whole-Building Hygrothermal Analysis

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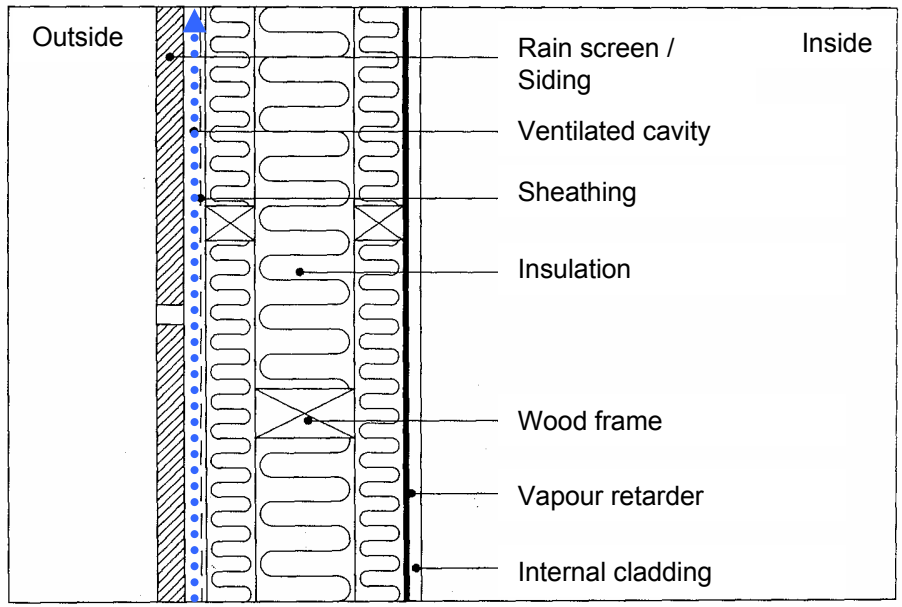
Introduction

- The ventilated exterior cladding is a common building component at the exterior side of building envelopes
- Ventilated cavities are not often modelled in building simulation tools
- We try to do it in *BSim*



Example of a wood frame wall with rain screen and ventilated cavity

Anticipations

- Better modelling of hygrothermal conditions in ventilated building envelope
- Better prediction of exterior surface temperature and humidity
- Possible extension to curtain walls, attics, crawl spaces, …?
- For later: Extension to variants where interactions with the indoor environment play a role

Ventilated Air Cavity Model

Air flow is driven by

- Wind pressure

$$\Delta P_{wind} = \Delta c \cdot ½ \cdot \rho \cdot v^2$$

- Bouyancy – stack effect

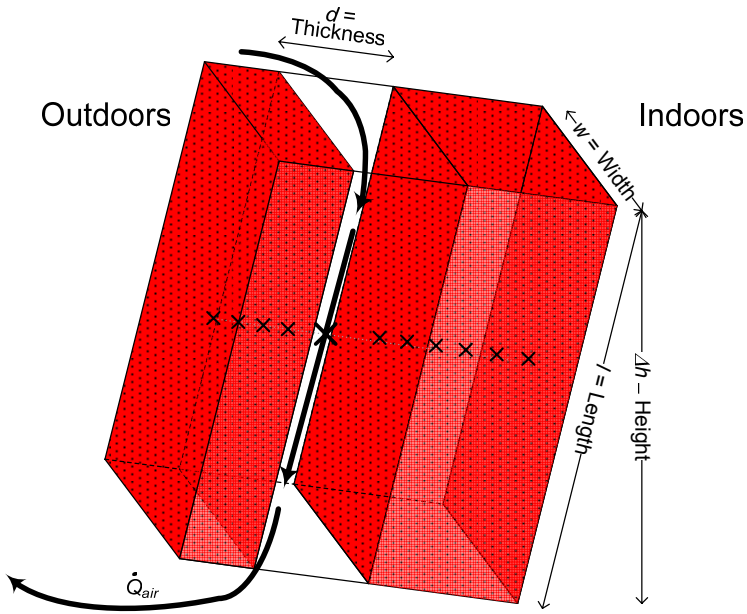
$$\Delta P_{stack} = g \cdot \frac{\partial \rho}{\partial T} \cdot \Delta T \cdot \Delta h$$

$$= g \cdot \frac{-P_{atm} \cdot M_{air}}{R \cdot T^2} \cdot \Delta T \cdot \Delta h$$

$$\approx -0.043 \cdot \Delta T \cdot \Delta h$$

- Total pressure

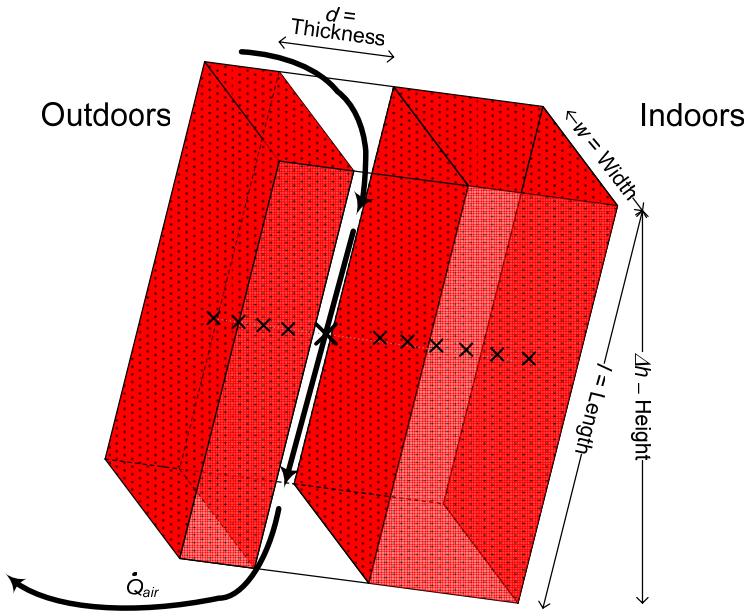
$$\Delta P_{cavity} = \Delta P_{wind} + \Delta P_{stack}$$



Air Velocity in Cavity

- The air velocity in the duct

$$v_{duct} = \sqrt{\frac{\left|\Delta P_{cavity}\right|}{1/2 \cdot \rho \cdot \xi_{total}}}$$

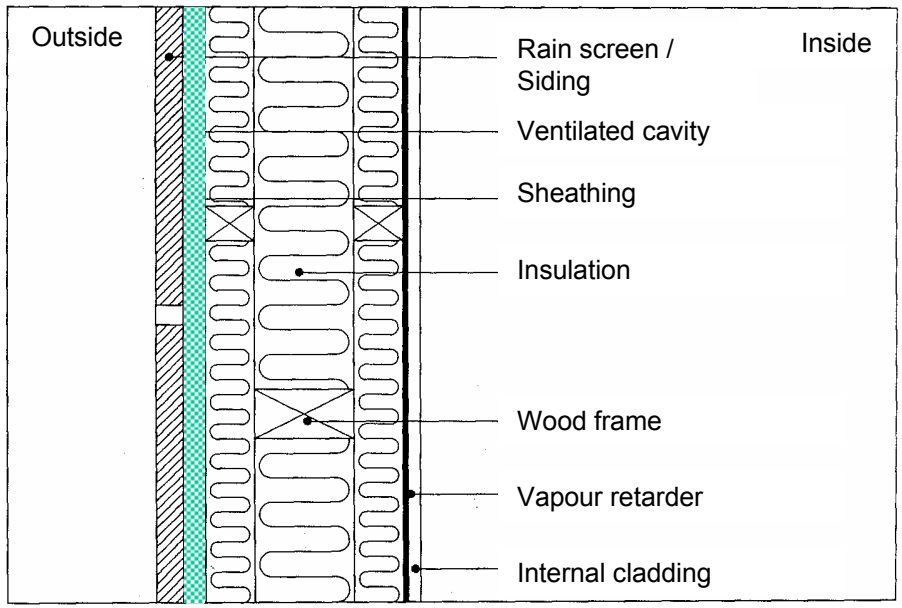


Cavity as Porous Layer

- With heat and moisture source terms:

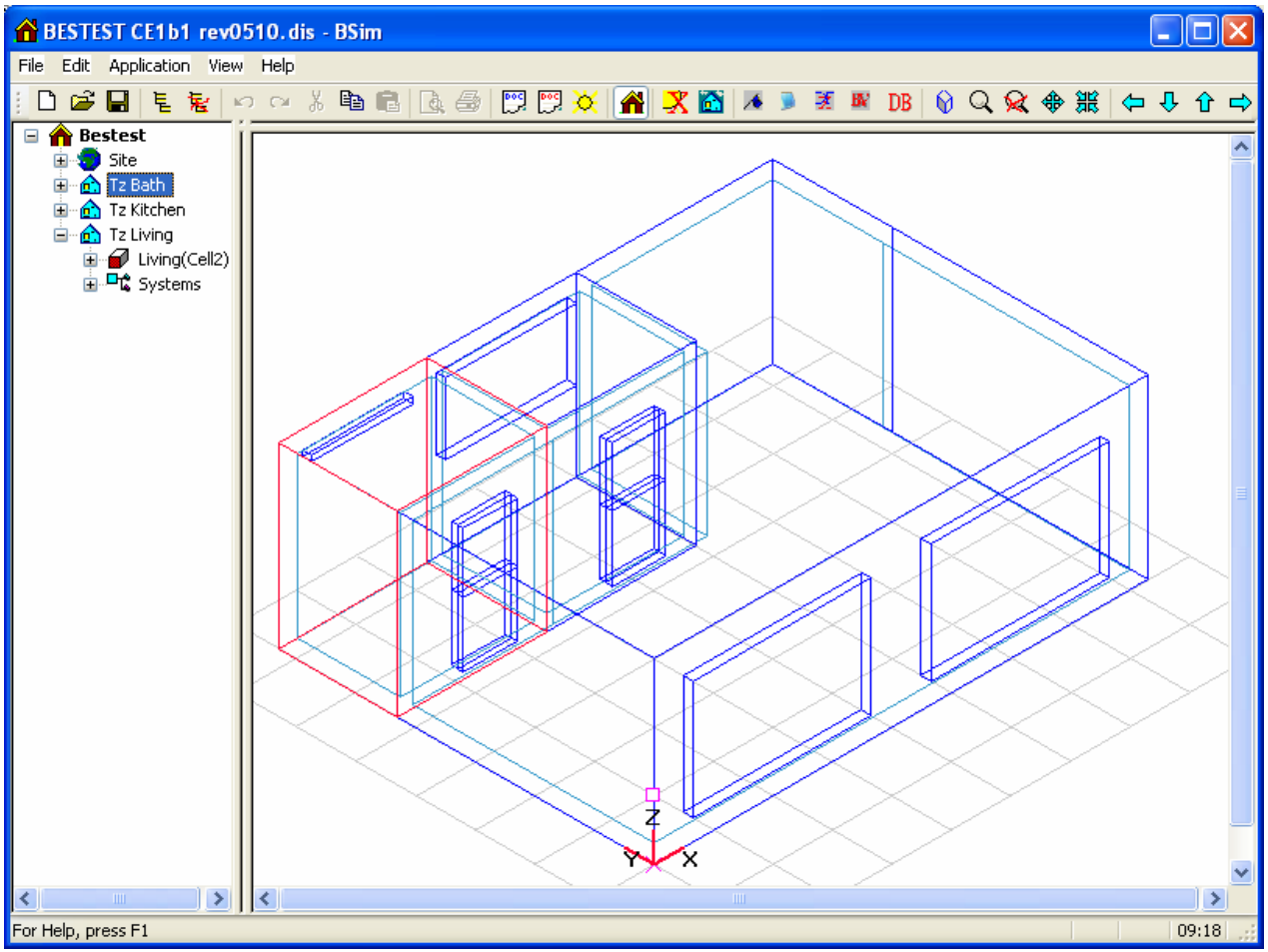
$$q_{vent} = \frac{\dot{Q}_{air}\left(\rho \cdot c_p\right)_{air}\left(T_{out} - T_{cav}\right)}{w \cdot l} = \frac{d}{l} v_{duct} \cdot \left(\rho \cdot c_p\right)_{air}\left(T_{out} - T_{cav}\right)$$

$$g_{vent} = \frac{\dot{Q}_{air}}{w \cdot l}\frac{\left(p_{out} - p_{cav}\right)}{R_v \cdot T} = \frac{\dot{Q}_{air}}{w \cdot l}\frac{\left(p_{out} - p_{cav}\right)}{130,600\ \frac{\mathrm{N \cdot m}}{\mathrm{kg}}} = \frac{d}{l} v_{duct}\frac{\left(p_{out} - p_{cav}\right)}{130,600\ \frac{\mathrm{N \cdot m}}{\mathrm{kg}}}$$



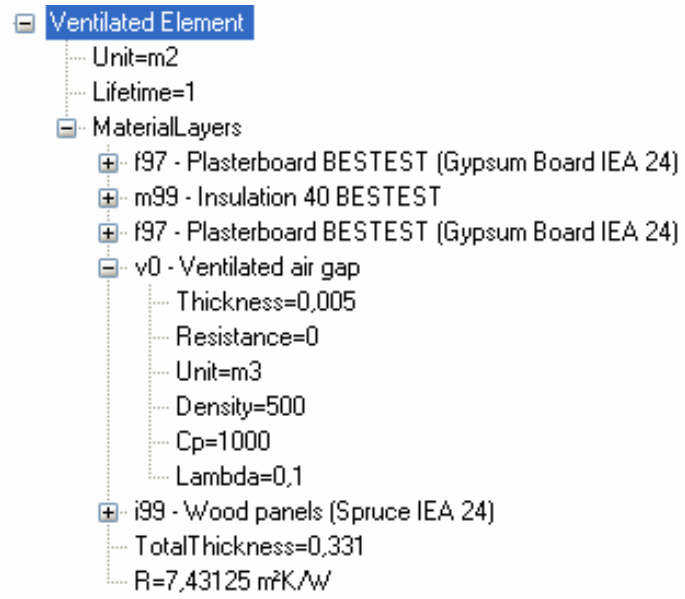
Example of a wood frame wall with rain screen and ventilated cavity

BESTEST model

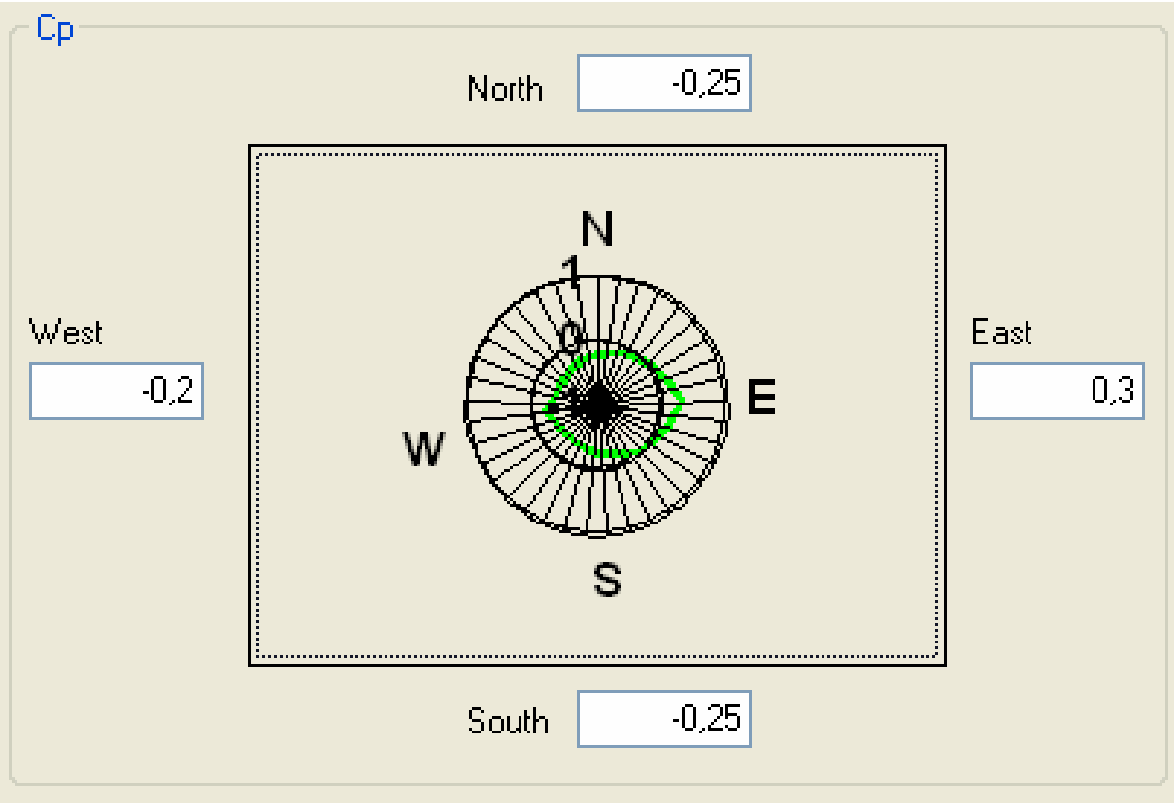


Element with cavity

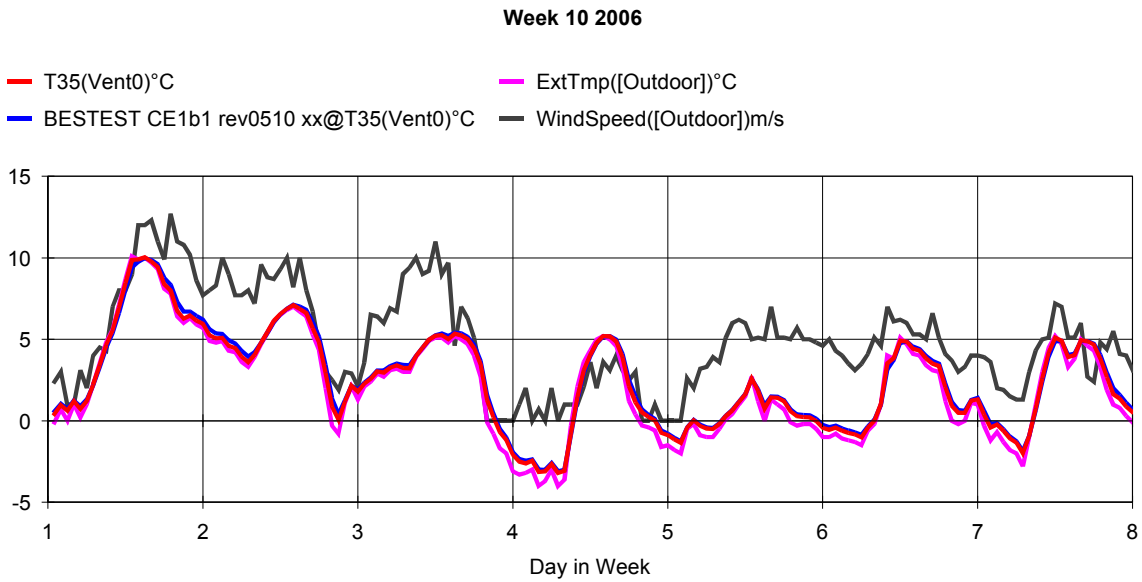
- 13 mm plasterboard
- 285 mm insulation
- 9 mm plasterboard
- ’5 mm’ air gap (12 mm)
- 19 mm wood panel



Wind pressure coefficient



Temperature in ventilated cavity



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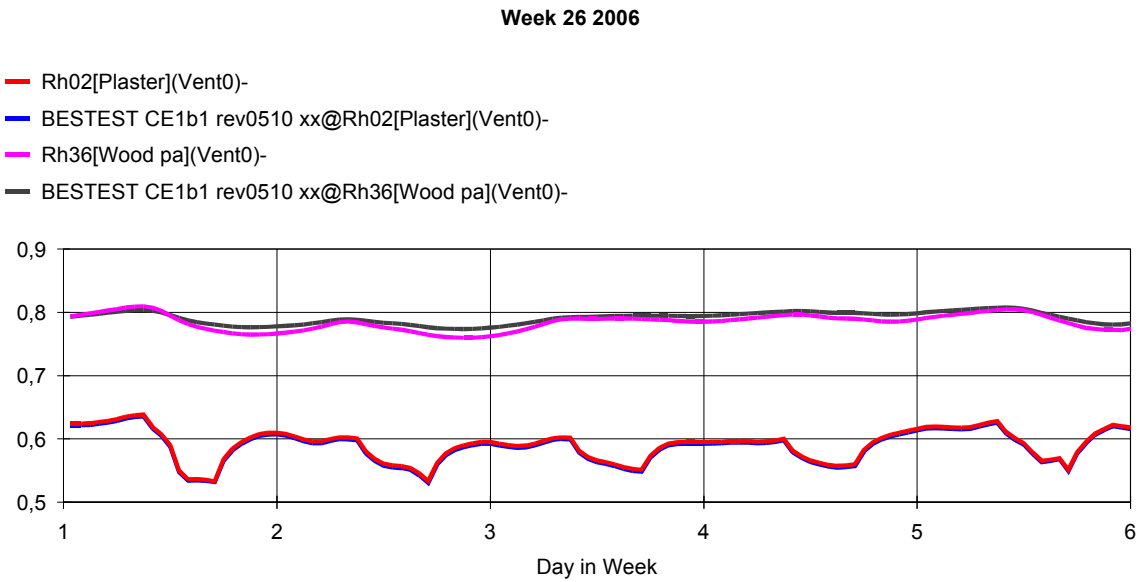
Relative humidity



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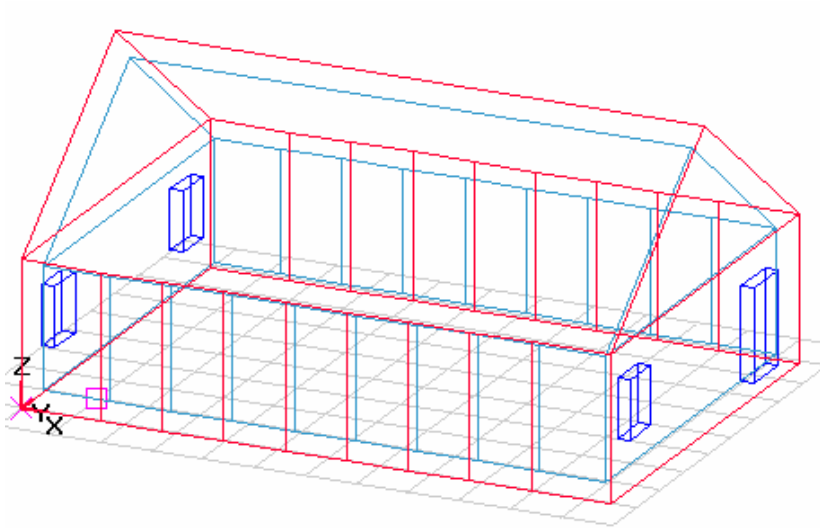
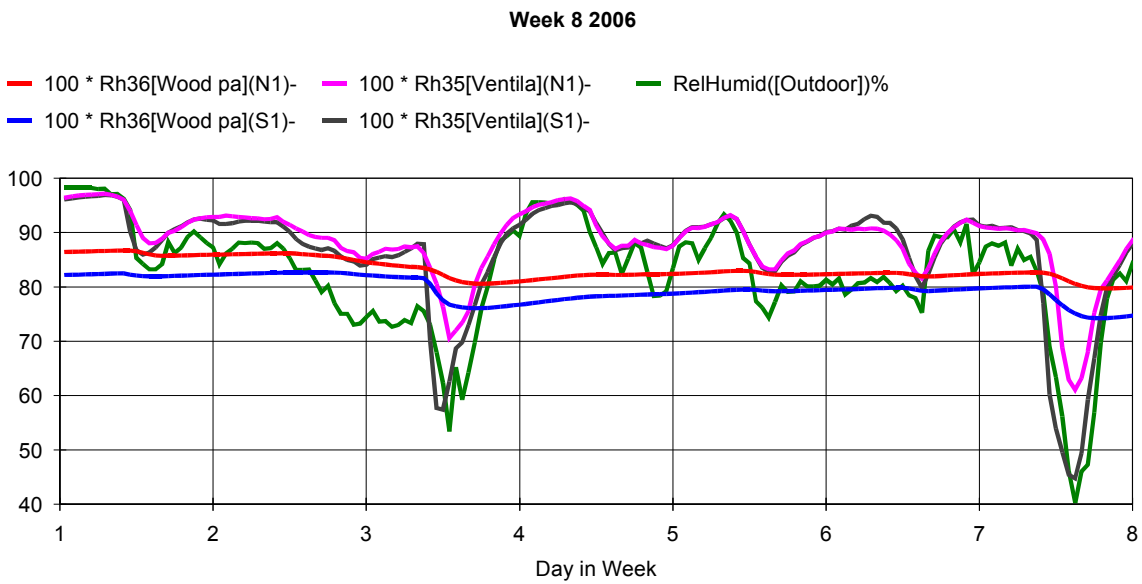
Research house



Relative humidity, week 8



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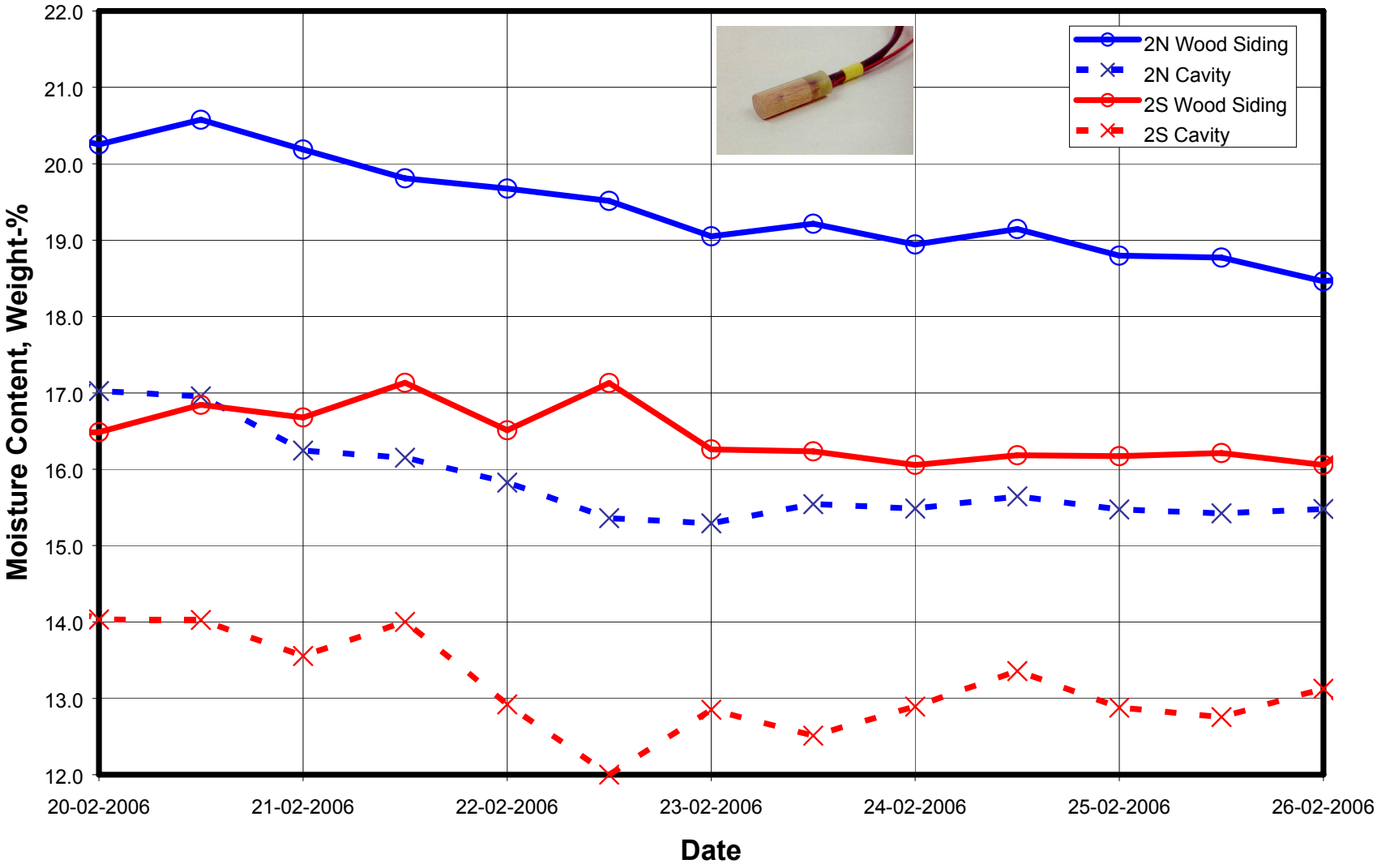
Measured Moisture Content



Conclusion and Further Work

- A model for calculating air flows in ventilated cavities has been implemented in the whole-building hygrothermal simulation tool *BSim*.
  - Exemplified by: BESTEST case
  - An existing research house with façade elements with ventilated cavities

Further Work

- empirical, and not the least analytical comparison and justification of the model is needed.
- inlet air come from other environments than the outdoors, e.g. from some of the indoor zones
- Afterwards, it is our intention to add to *BSim* a model for filtration air flow through the envelope